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# Supplemental Material

# Comparing the Health Effects of Ambient Particulate Matter Estimated Using Ground-Based versus Remote Sensing Exposure Estimates

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**Methods. Detailed Description of the Individual and Ecological Variables included in the Cox proportional Hazards Models**

Every model included 13 terms to characterize current and former smoking status as well as smoking duration, amount, and age started smoking; a continuous variable was used to assess exposure to second hand cigarette smoke (hours/day exposed); a variable with seven terms was used to quantify exposure to $PM_{2.5}$ in the workplace for each of the subject's major lifetime occupation; another variable had self-reported exposure to dust and fumes at work; a variable with two terms representing marital status (separated/divorced/widowed or single versus married); a variable with two terms characterizing level of education (high school, more than high school versus less than high school); two body mass index (BMI) variables (linear and squared terms for BMI); a variable with two terms each assessing beer/wine/liquor consumption (beer, missing beer, wine, missing wine, liquor, missing liquor); and variables that indicate quintile ranges of a dietary vegetable/fruit/fiber index (four terms) and quintile ranges of dietary fat index (four terms) and one term for missing nutrition information.

These ecologic characteristics are documented elsewhere and included: median household income; percentage of people with < 125% of poverty-level income; percentage of persons over the age of 16 years who are unemployed; percentage of adults with less than $12^{th}$ grade education; and percentage of the population who were Black or Hispanic. These ecological variables were entered at the ZIP code level and the ZIP code minus the county-level mean. The primary analysis used data from 1990 (see Table 4 in the main text). Sensitivity analysis using ecological covariates from 2000 is presented in Table S6.

Table S1. Distribution (n, %) of selected participant characteristics at enrollment (1982), ACS CPS II cohort, U.S., compared to those excluded

| Characteristics | Included Participants (668,629) n (%) | Mean (SD) PM2.5 BMELUR 02-04 | Excluded Participants (515,958) n (%) |
|---|---|---|---|
| Age (years) | | | |
| <40 | 29,602 (4.4) | 12.2 (2.7) | 24,738 (4.8) |
| 40-49 | 137,509 (20.6) | 11.9 (2.6) | 101,427 (19.7) |
| 50-59 | 245,008 (36.6) | 12.0 (2.6) | 174,066 (33.7) |
| 60-69 | 117,988 (26.6) | 12.0 (2.7) | 139,216 (27.0) |
| 70-79 | 66,498 (10.0) | 12.0 (2.7) | 62,807 (12.2) |
| ≥80 | 12,024 (1.8) | 12.1 (2.7) | 13,704 (2.7) |
| Race | | | |
| White | 632,508 (94.6) | 11.9 (2.6) | 472,077 (92.5) |
| Black | 25,504 (3.8) | 13.1 (2.4) | 26,479 (5.2) |
| Other | 10,617 (1.6) | 12.3 (4.0) | 11,735 (2.3) |
| Sex | | | |
| Male | 292,580 (43.8) | 11.9 (2.7) | 215,738 (41.8) |
| Female | 376,049 (56.2) | 12.0 (2.7) | 300,220 (58.2) |
| Education | | | |
| <High School | 78,363 (11.7) | 12.2 (2.6) | 95,213 (19.1) |
| High School | 207,579 (31.0) | 12.0 (2.6) | 168,846 (33.9) |
| ≥High School | 382,687 (57.2) | 11.9 (2.7) | 233,323 (46.9) |
| BMI ($kg/m^2$) | | | |
| <18.5 | 11,897 (1.8) | 12.0 (2.7) | 38,507 (7.5) |
| 18.5-24.9 | 338,290 (50.6) | 11.9 (2.7) | 236,673 (45.9) |
| 25-29.9 | 242,007 (36.2) | 12.0 (2.6) | 176,638 (34.2) |
| ≥30 | 76,435 (11.4) | 12.2 (2.6) | 64,140 (12.4) |
| Marital Status | | | |
| Single | 21,963 (3.3) | 12.4 (2.6) | 16,813 (3.3) |
| Married | 563,805 (84.3) | 11.9 (2.7) | 419,205 (82.5) |
| Other | 82,861 (12.4) | 12.2 (2.7) | 72,240 (14.2) |
| Cigarette Smoking Status | | | |
| Never | 299,354 (44.8) | 12.0 (2.7) | 183,110 (35.5) |
| Current | 129,778 (19.4) | 12.1 (2.7) | 110,299 (21.4) |
| Former | 172,591 (25.8) | 11.9 (2.7) | 116,789 (22.6) |
| Pipe/cigar only | 66,906 (10.0) | 11.9 (2.6) | 34,669 (6.7) |

Note: The sum for excluded participants does not always equal the total due to missing data for some variables.

**Commentary on Differences between Included and Excluded Subjects**

In comparing those excluded to those in the analytical cohort, we see a higher proportion over 70 years in excluded. There is a slightly lower proportion of whites and higher proportion of blacks excluded. Slightly more of the excluded subjects are obese, but also more are underweight. There is also a lower proportion of never smokers excluded.

Table S2. Results of the Cox Proportional Hazard Modeling with adjustment for individual or individual plus year 1990 ecologic covariates. Hazard ratios expressed over an IDR increment.

| | Diseases of the circulatory system | | | | Ischemic heart disease | | | |
|---|---|---|---|---|---|---|---|---|
| | N=100,102 | | | | N=45,624 | | | |
| Air Pollution | Fully-adjusted HR (95% CI) | AIC (1,587,000s) | Fully-adjusted HR (95% CI) + 1990 Ecological Confounders | AIC (1,587,000s) | Fully-adjusted HR (95% CI) | AIC (726,000s) | Fully-adjusted HR (95% CI) + 1990 Ecological Confounders | AIC (726,000s) |
| PM2.5 HBMCMAQ 02-04 | 1.06 (1.04-1.07) | 434 | 1.06 (1.04-1.08) | 94 | 1.09 (1.07-1.12) | 688 | 1.07 (1.04-1.10) | 315 |
| PM2.5 BME 02-04 | 1.08 (1.06-1.10) | 388 | 1.08 (1.06-1.10) | 65 | 1.12 (1.10-1.15) | 650 | 1.09 (1.07-1.12) | 296 |
| PM2.5 BMELUR 02-04 | 1.10 (1.08-1.11) | 340 | 1.09 (1.07-1.11) | 33 | 1.13 (1.10-1.15) | 636 | 1.09 (1.07-1.12) | 290 |
| PM2.5 BMELUR CT 02-04 | 1.09 (1.07-1.10) | 364 | 1.08 (1.06-1.10) | 51 | 1.12 (1.10-1.15) | 643 | 1.09 (1.07-1.12) | 292 |
| PM2.5 BMELURRS 02-04 | 1.08 (1.06-1.10) | 388 | 1.07 (1.06-1.09) | 66 | 1.12 (1.09-1.14) | 652 | 1.09 (1.06-1.12) | 297 |
| PM2.5 BMELURRS CT 02-04 | 1.08 (1.06-1.09) | 396 | 1.07 (1.05-1.09) | 68 | 1.11 (1.09-1.14) | 660 | 1.09 (1.06-1.11) | 301 |
| PM2.5 RS GWR CT 02-04 | 1.07 (1.06-1.09) | 411 | 1.07 (1.05-1.09) | 88 | 1.08 (1.05-1.10) | 711 | 1.07 (1.04-1.10) | 321 |
| PM2.5 RS no GWR CT 02-04 | 1.04 (1.03-1.06) | 462 | 1.02 (1.00-1.04) | 131 | 1.08 (1.06-1.11) | 707 | 1.05 (1.02-1.09) | 331 |
| PM2.5 BMELUR 01-06 | 1.10 (1.08-1.12) | 336 | 1.09 (1.07-1.11) | 36 | 1.13 (1.10-1.15) | 639 | 1.09 (1.07-1.12) | 293 |
| PM2.5 RS 01-06 | 1.05 (1.04-1.07) | 447 | 1.05 (1.02-1.07) | 115 | 1.12 (1.10-1.15) | 658 | 1.10 (1.07-1.14) | 298 |

Note 1: There are 43 variables in the model including $PM_{2.5}$ for individual only and 55 in fully adjusted.

Table S3. Descriptive Statistics for the Central Monitor Exposure Estimate.

| Air Pollution | N | Mean (SD) | Minimum | 10th percentile | 1st quartile | 2nd quartile | 3rd quartile | 90th percentile | Maximum | IQR | Range |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Central monitor 99-00 | 379618 | 14.0 (3.0) | 5.8 | 10.2 | 11.8 | 14.4 | 16.0 | 17.9 | 22.2 | 4.2 | 16.4 |

Table S4. Results of the Cox Proportional Hazard Modeling with adjustment for individual plus year 1990 ecologic covariates plus MSA size or elevation or RE model.

| | Diseases of the circulatory system | | | | |
|---|---|---|---|---|---|
| | N=100,102 | | | | |
| Air Pollution | Fully-adjusted HR (95% CI) + 1990 Ecologicals | + MSA size indicator | + elevation 90th percentile | + elevation 95th percentile | Fully-adjusted HR (95% CI) + 1990 Ecological Confounders RE model (county)* |
| PM2.5 HBMCMAQ 02-04 | 1.09 (1.06-1.12) | 1.08 (1.05-1.11) | 1.09 (1.07-1.13) | 1.10 (1.07-1.13) | - |
| PM2.5 BME 02-04 | 1.12 (1.09-1.15) | 1.11 (1.08-1.14) | 1.12 (1.09-1.15) | 1.12 (1.09-1.15) | - |
| PM2.5 BMELUR 02-04 | 1.14 (1.11-1.17) | 1.13 (1.10-1.16) | 1.14 (1.11-1.17) | 1.14 (1.11-1.17) | 1.16 (1.12-1.20) 0.00518791 |
| PM2.5 BMELUR CT 02-04 | 1.12 (1.09-1.15) | 1.11 (1.09-1.14) | 1.12 (1.10-1.15) | 1.12 (1.10-1.15) | 1.12 (1.09-1.16) 0.0051866 |
| PM2.5 BMELUR 01-06 | 1.14 (1.11-1.17) | 1.13 (1.10-1.17) | 1.14 (1.11-1.17) | 1.14 (1.11-1.17) | - |
| PM2.5 BMELURRS 02-04 | 1.11 (1.08-1.14) | 1.10 (1.07-1.13) | 1.11 (1.08-1.14) | 1.11 (1.08-1.14) | - |
| PM2.5 BMELURRS CT 02-04 | 1.11 (1.08-1.13) | 1.10 (1.07-1.13) | 1.11 (1.08-1.13) | 1.11 (1.08-1.13) | - |
| PM2.5 RS 01-06 | 1.05 (1.03-1.07) | 1.04 (1.02-1.06) | 1.05 (1.02-1.07) | 1.05 (1.02-1.07) | - |
| PM2.5 RS GWR CT 02-04 | 1.08 (1.06-1.11) | 1.08 (1.05-1.10) | 1.08 (1.06-1.11) | 1.08 (1.06-1.11) | 1.08 (1.05-1.11) 0.00547513 |
| PM2.5 RS no GWR CT 02-04 | 1.02 (1.00-1.04) | 1.01 (0.99-1.03) | 1.02 (1.00-1.04) | 1.02 (1.00-1.04) | 1.02 (0.99-1.05) 0.00585872 |

Note 1: adjustments are not cumulative. MSA size only, elevation only etc.
Note 2: Hazard ratios expressed over a 10 μg/m3 increment.
* Results shown only for the BMELUR estimates assigned to the CT and the geocoded residence and RS 1 km surfaces for time-matched comparison. Models shown in this column have the AIC below the HR for comparison of model fit between the models.

Table S5. Results of the Cox Proportional Hazard Modeling with adjustment for individual plus year 1990 ecologic covariates plus MSA size or elevation or RE model.

| | Ischemic Heart Disease | | | | |
|---|---|---|---|---|---|
| | N=45,624 | | | | |
| Air Pollution | Fully-adjusted HR (95% CI) + 1990 Ecologicals | + MSA size indicator | + elevation 90th percentile | + elevation 95th percentile | Fully-adjusted HR (95% CI) + 1990 Ecological Confounders RE model (county)* |
| PM2.5 HBMCMAQ 02-04 | 1.11 (1.07-1.16) | 1.08 (1.04-1.13) | 1.12 (1.07-1.16) | 1.12 (1.08-1.17) | - |
| PM2.5 BME 02-04 | 1.15 (1.10-1.19) | 1.12 (1.08-1.17) | 1.15 (1.10-1.19) | 1.15 (1.11-1.19) | - |
| PM2.5 BMELUR 02-04 | 1.15 (1.11-1.19) | 1.12 (1.08-1.17) | 1.15 (1.11-1.20) | 1.15 (1.11-1.20) | 1.16 (1.10-1.22) 0.0141186 |
| PM2.5 BMELUR CT 02-04 | 1.14 (1.10-1.18) | 1.12 (1.08-1.16) | 1.14 (1.10-1.19) | 1.14 (1.10-1.19) | 1.14 (1.09-1.20) 0.0141060 |
| PM2.5 BMELUR 01-06 | 1.15 (1.11-1.19) | 1.12 (1.08-1.17) | 1.15 (1.11-1.20) | 1.15 (1.11-1.20) | - |
| PM2.5 BMELURRS 02-04 | 1.13 (1.09-1.17) | 1.11 (1.07-1.15) | 1.14 (1.09-1.18) | 1.14 (1.10-1.18) | - |
| PM2.5 BMELURRS CT 02-04 | 1.12 (1.08-1.16) | 1.10 (1.06-1.14) | 1.13 (1.09-1.17) | 1.13 (1.09-1.17) | - |
| PM2.5 RS 01-06 | 1.10 (1.07-1.14) | 1.08 (1.05-1.12) | 1.10 (1.07-114) | 1.10 (1.07-1.14) | - |
| PM2.5 RS GWR CT 02-04 | 1.08 (1.05-1.12) | 1.06 (1.03-1.10) | 1.09 (1.05-1.12) | 1.09 (1.05-1.13) | 1.08 (1.03-1.12) 0.0145285 |
| PM2.5 RS no GWR CT 02-04 | 1.06 (1.02-1.09) | 1.04 (1.00-1.07) | 1.06 (1.02-1.09) | 1.06 (1.02-1.09) | 1.06 (1.01-1.10) 0.0144213 |

Note 1: Adjustments are not cumulative. MSA size only, elevation only etc.
Note 2: Hazard ratios expressed over a 10 $\mu g/m^3$ increment.
Results shown only for the BMELUR estimates assigned to the CT and the geocoded residence and RS 1 km surfaces for time-matched comparison. Models shown in this column have the AIC below the HR for comparison of model fit between the models.

Table S6. Results of the Cox Proportional Hazard Modeling with adjustment for individual or individual plus year 2000 ecologic covariates. Hazard ratios expressed over a 10 µg/m3 increment.

| | Diseases of the circulatory system | | | | Ischemic heart disease | | | |
|---|---|---|---|---|---|---|---|---|
| | N=100,102 | | | | N=45,624 | | | |
| Air Pollution | Fully-adjusted HR (95% CI) | AIC (1,587,000s) | Fully-adjusted HR (95% CI) + 2000 Ecological Confounders | AIC (1,587,000s) | Fully-adjusted HR (95% CI) | AIC (726,000s) | Fully-adjusted HR (95% CI) + 2000 Ecological Confounders | AIC (726,000s) |
| PM2.5 HBMCMAQ 02-04 | 1.09 (1.07-1.12) | 434 | 1.07 (1.04-1.10) | 92 | 1.15 (1.11-1.19) | 688 | 1.08 (1.04-1.13) | 335 |
| PM2.5 BME 02-04 | 1.13 (1.10-1.15) | 388 | 1.10 (1.07-1.13) | 69 | 1.19 (1.15-1.23) | 650 | 1.12 (1.07-1.16) | 320 |
| PM2.5 BMELUR 02-04 | 1.15 (1.13-1.18) | 340 | 1.12 (1.09-1.15) | 40 | 1.20 (1.16-1.24) | 636 | 1.13 (1.08-1.17) | 314 |
| PM2.5 BMELUR CT 02-04 | 1.13 (1.11-1.16) | 364 | 1.11 (1.08-1.13) | 55 | 1.19 (1.15-1.23) | 643 | 1.12 (1.08-1.16) | 314 |
| PM2.5 BMELURRS 02-04 | 1.12 (1.09-1.14) | 388 | 1.09 (1.07-1.12) | 68 | 1.18 (1.14-1.22) | 652 | 1.11 (1.07-1.15) | 319 |
| PM2.5 BMELURRS CT 02-04 | 1.11 (1.09-1.13) | 396 | 1.09 (1.06-1.12) | 70 | 1.17 (1.13-1.20) | 660 | 1.10 (1.06-1.14) | 322 |
| PM2.5 RS GWR CT 02-04 | 1.09 (1.07-1.11) | 411 | 1.07 (1.04-1.09) | 86 | 1.10 (1.06-1.13) | 711 | 1.06 (1.02-1.10) | 339 |
| PM2.5 RS no GWR CT 02-04 | 1.04 (1.03-1.06) | 462 | 1.00 (0.98-1.02) | 116 | 1.09 (1.06-1.12) | 707 | 1.03 (1.00-1.06) | 347 |
| PM2.5 BMELUR 01-06 | 1.16 (1.13-1.19) | 336 | 1.12 (1.09-1.15) | 44 | 1.20 (1.16-1.25) | 639 | 1.12 (1.08-1.17) | 317 |
| PM2.5 RS 01-06 | 1.05 (1.04-1.07) | 447 | 1.03 (1.01-1.05) | 107 | 1.12 (1.10-1.15) | 658 | 1.09 (1.06-1.12) | 319 |

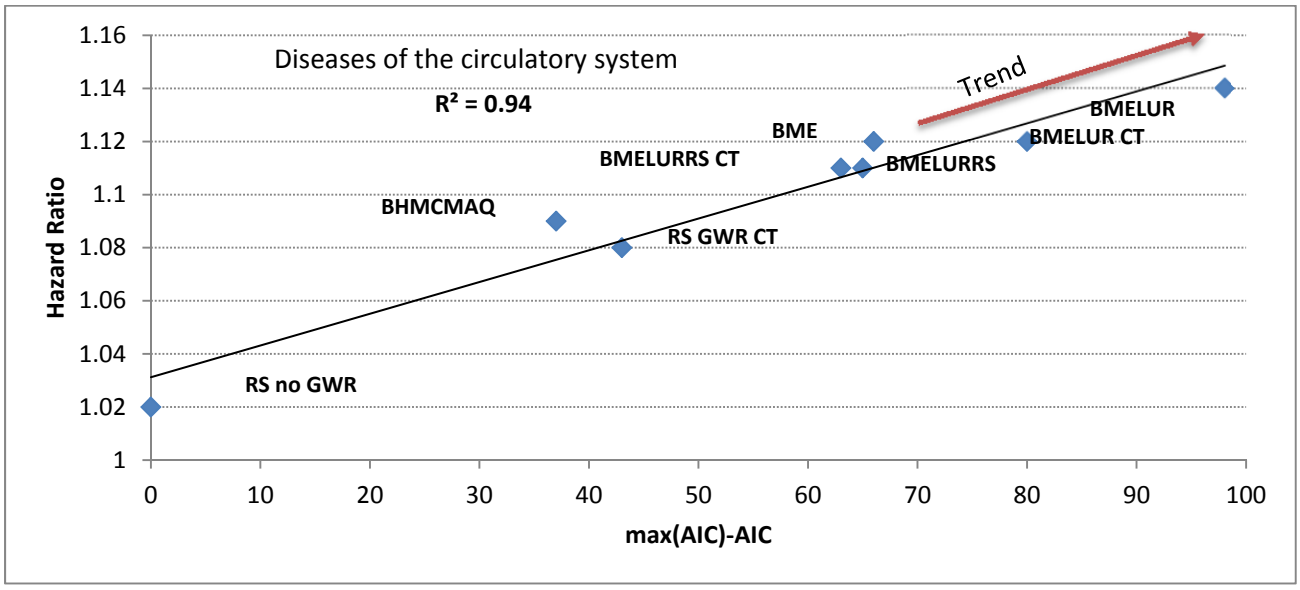
Note there are 43 variables in the model including PM2.5 for individual only and 55 in fully adjusted.

Table S7. Results of the Cox proportional hazard modeling with adjustment for individual or individual plus year 1990 ecologic covariates for mortality from diabetes. Hazard ratios expressed over a 10 μg/$m^3$ increment.

| | Diabetes (ICD XX) | | | |
|---|---|---|---|---|
| | N=4,886 | | | |
| Air Pollution | Fully-adjusted HR (95% CI) | AIC (77,000s) | Fully-adjusted HR (95% CI) + 1990 Ecological Confounders | AIC (77,000s) |
| PM2.5 HBMCMAQ 02-04 | 1.04 (0.93-1.16) | 604 | 1.15 (1.01-1.30) | 578 |
| PM2.5 BME 02-04 | 1.02 (0.91-1.13) | 604 | 1.08 (0.96-1.22) | 581 |
| PM2.5 BMELUR 02-04 | 1.12 (1.01-1.24) | 600 | 1.18 (1.05-1.33) | 575 |
| PM2.5 BMELUR CT 02-04 | 1.10 (1.00-1.22) | 601 | 1.17 (1.05-1.30) | 575 |
| PM2.5 BMELURRS 02-04 | 1.06 (0.96-1.17) | 603 | 1.12 (1.00-1.25) | 579 |
| PM2.5 BMELURRS CT 02-04 | 1.06 (0.96-1.17) | 603 | 1.13 (1.01-1.25) | 578 |
| PM2.5 RS GWR CT 02-04 | 1.01 (0.92-1.10) | 604 | 1.11 (1.00-1.24) | 579 |
| PM2.5 RS no GWR CT 02-04 | 0.97 (0.89-1.05) | 604 | 1.01 (0.92-1.11) | 583 |
| PM2.5 BMELUR 01-06 | 1.11 (1.00-1.24) | 601 | 1.18 (1.05-1.33) | 575 |
| PM2.5 RS 01-06 | 1.00 (0.93-1.08) | 604 | 1.08 (0.98-1.18) | 580 |

Note 1: There are 43 variables in the model including $PM_{2.5}$ for individual only and 55 in fully adjusted.

Figure S1. Fully-Adjusted hazard ratios (HR) from Table 2 for deaths of the circulatory system and IHD with HR plotted against AIC statistics to illustrate the effect of model fit on the HR among seven exposure models.



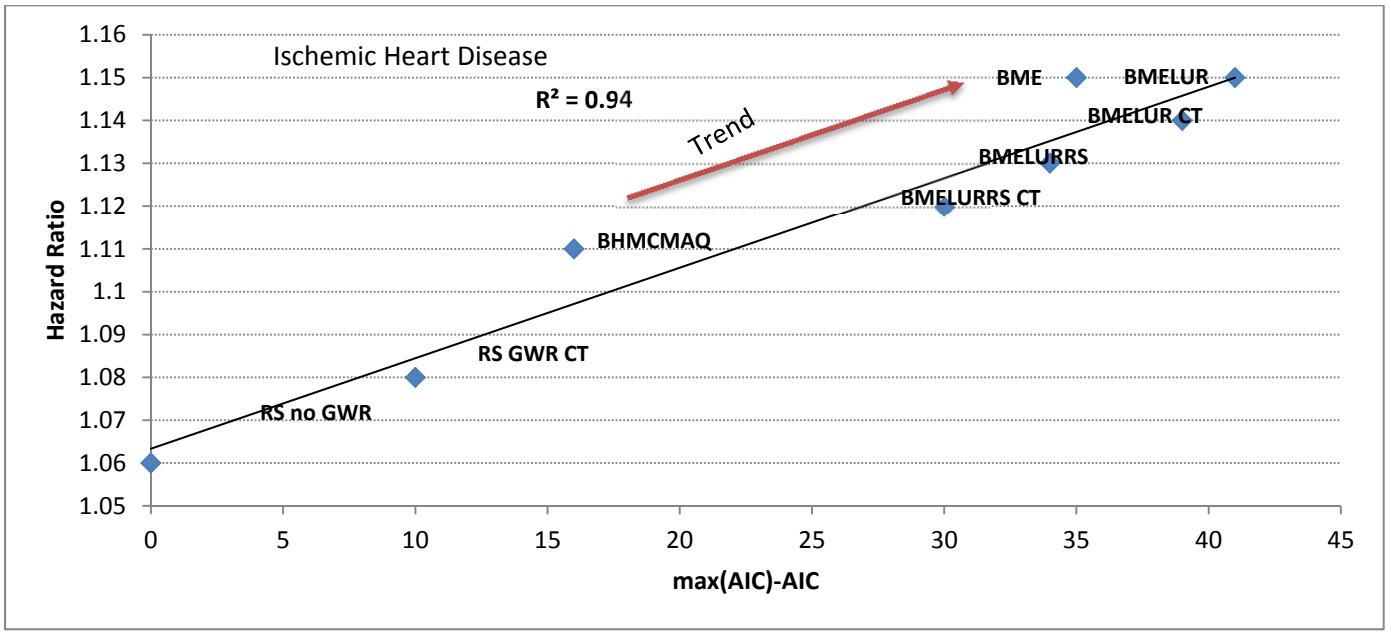



Figure S2. Concentration response plot for PM2.5 BMELUR 02-04 with two degrees of freedom for circulatory mortality

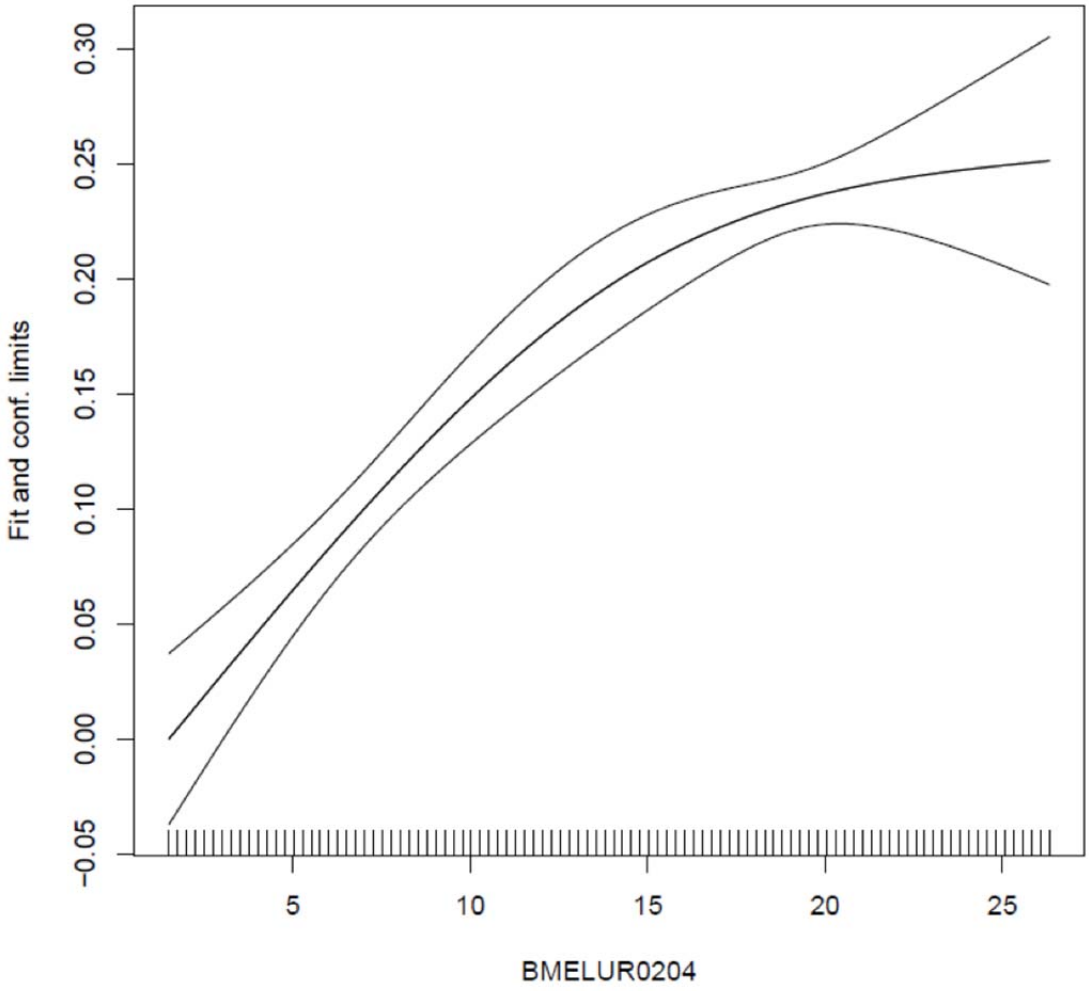


Figure S3. Concentration response plot for PM2.5 RS no GWR CT 02-04 with two degrees of freedom for circulatory mortality